Friends & Foes: Preventing Selfishness in Mobile Ad Hoc Networks

Hugo Miranda and Luís Rodrigues
hmiranda@di.fc.ul.pt

Universidade de Lisboa
DIAL-NP - LaSIGE
Outline

- Motivation
  - Load balancing
  - Selfishness prevention
- Protocol overview
- Load balancing evaluation
- Conclusions
Motivation

- Mobile Ad Hoc Networks (MANETs) depend on the individual behavior of the nodes.
- Open MANETs users may be “resource selfish.”
- Routing protocols may exacerbate the problem if routes remain static.
Dynamic Source Routing (DSR)

- 3 routing message types: requests, replies and errors
- Data messages include the route to be followed
- To minimize routing messages:
  - learn routes in data messages
  - if a route is known, reply to route requests
Load-balancing in DSR

Two scenarios with:

- 36 nodes, on a $6 \times 6$ matrix
- nodes reach each of their neighbors
- no node movement
- no transmission errors
- each node $(i, j)$ sends 20 UDP datagrams to:
  - **Scenario #1** Node $(j, i)$
  - **Scenario #2** Node (2, 3)
Scenario #1

- \(3468 (2997 + 471)\) MAC frames sent
- 9 (25%) of the nodes sent 1802 (52%) of the frames
- 3 (8%) of the nodes sent 773 (22%) of the frames

- 50 routes used (12 of them once)
- Node (2, 3) sent 337 frames in 24 routes
Scenario #2

- 1561(1496 + 65) MAC frames sent
- 42 routes used (2 of them once)

- The 8 nodes surrounding (2, 3) have sent 90 frames on average. Standard deviation: 31.5
Therefore...

- MANET routing protocols privilege efficiency over load balancing
- Some nodes may unfairly exhaust their resources serving others
- The lack of load balancing mechanisms and the absence of consequences from selfish behavior, motivates users for being “resource selfish”
Related Work

• Path rater
  • Notifies routing protocols to avoid selfish nodes
  • Selfish nodes may freely use the network

• Confidant
  • Nodes refuse to forward messages from those with a bad reputation
  • Nodes are always forbidden to be selfish (no fairness)
Related Work - cont.

- Terminodes
  - Virtual currency possibly mapped in real money
  - Each hop of a message would charge some *nuglets* (*beans*)
  - Tamper-proof device prevents frauds
  - Requires PKI

- Power-aware routing
  - Different metrics
  - Rely on the information provided by each node
Desirable Properties

- Fair selfishness, if some node becomes highly loaded
  - Nodes should remember the past behavior of other nodes
- The protocol should be optional
- Low overhead
Selfishness Prevention Protocol

- Fair selfishness: improves load balancing
- Excludes selfish nodes
  - Node reintegration
- Charges per message
- Requirements
  - A route composed of only non-selfish nodes must exist between any two selfish nodes
  - Selfish nodes do not cooperate between them
Algorithm overview

Periodically, each node $p$ broadcasts:

**friends**$_p$ The set of nodes to whom he is willing to provide services

**foes**$_p$ The set of nodes to whom he refuses to provide services

**selfish**$_p$ The set of nodes that lied to him, by declaring him as friend

Nodes rate their neighbors by crossing the information received
Internal data structures

Each node $p$ keeps a record for each of his neighbors $q$ with:

- $\text{credits}_q^p$ Messages forwarded on behalf of $q$
- $\text{maxCredtits}_q^p$ Acceptable number of credits
- $\text{friends}_q^p$ Nodes to whom $q$ provides services
- $\text{foes}_q^p$ Nodes to whom $q$ refuses to provide services
- $\text{deadbeat}_q^p$ Evaluates if $q$ is still in the neighborhood
Who’s selfish?

- Decision is taken locally. Node $q$ with the ratio:

$$\frac{\# friends_q}{\# friends_p + \# foes_p}$$

bellow an acceptable threshold will be considered selfish by $p$.

- Selfish nodes will only be able to send messages until their credits reach 0
Other considerations

- Re-integration;
- Protocol transparency;
- Subverting the protocol;
- Integration with routing protocols
  - Do not forward route discovery messages issued by foe nodes
  - Send route errors for messages to be forwarded to foe neighbors
Evaluation # 1

- $3559(3060 + 499)$ MAC frames sent

- 9 (25%) of the nodes sent 1721 (48%) of the frames

- 3 (8%) of the nodes sent 687 (19.3%) of the frames

- 53 [50] routes used (12 of them once)

Evaluation # 2

- $1632(1553 + 79)$ MAC frames sent
- $84 [42]$ routes used (20 of them once)

- The 8 nodes surrounding $(2, 3)$ are closer to average. Standard deviation: $19.7 [31.5]$
Summary of Evaluation

- Slightly increase on:
  - Number of frames
  - Number of routes
- New routes alleviate overloaded nodes
Future Work

- How to make the protocol more robust;
- Validation of the protocol;
- Investigate the use of other metrics;
Conclusions

- When nodes remain in the same position, routing protocols may present unfair load distribution.
- Selfishness prevention in MANETs is a relatively new subject.
- A new algorithm that enhances load balancing while banning selfish users from the MANET was presented.